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(54) Flaw detection method

(57) Surface flaws in a magnetisable object are detected and recorded for subsequent reference by applying to the flawed surface a sheet of material which, when the object is magnetised, becomes magnetised itself but only in those regions which overlie the or each surface flaw and which can be removed from the test surface without destroying by such removal the flaw pattern record so obtained.

In one embodiment the sheet of material is obtained by spraying as an aerosol a solution of ferromagnetic particles, solvents, base lacquers and propellants which then dries to a skin which can subsequently be peeled off the test surface.

In another embodiment the sheet is a sheet of magnetic recording tape which when removed from the surface is developed by applying a suitable magnetic ink to it.

In the latter embodiment the magnetic ink may be applied as an aerosol spray which then dries by evaporation.

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The drawing originally filed was informal and the print here reproduced is taken from a later filed formal copy.

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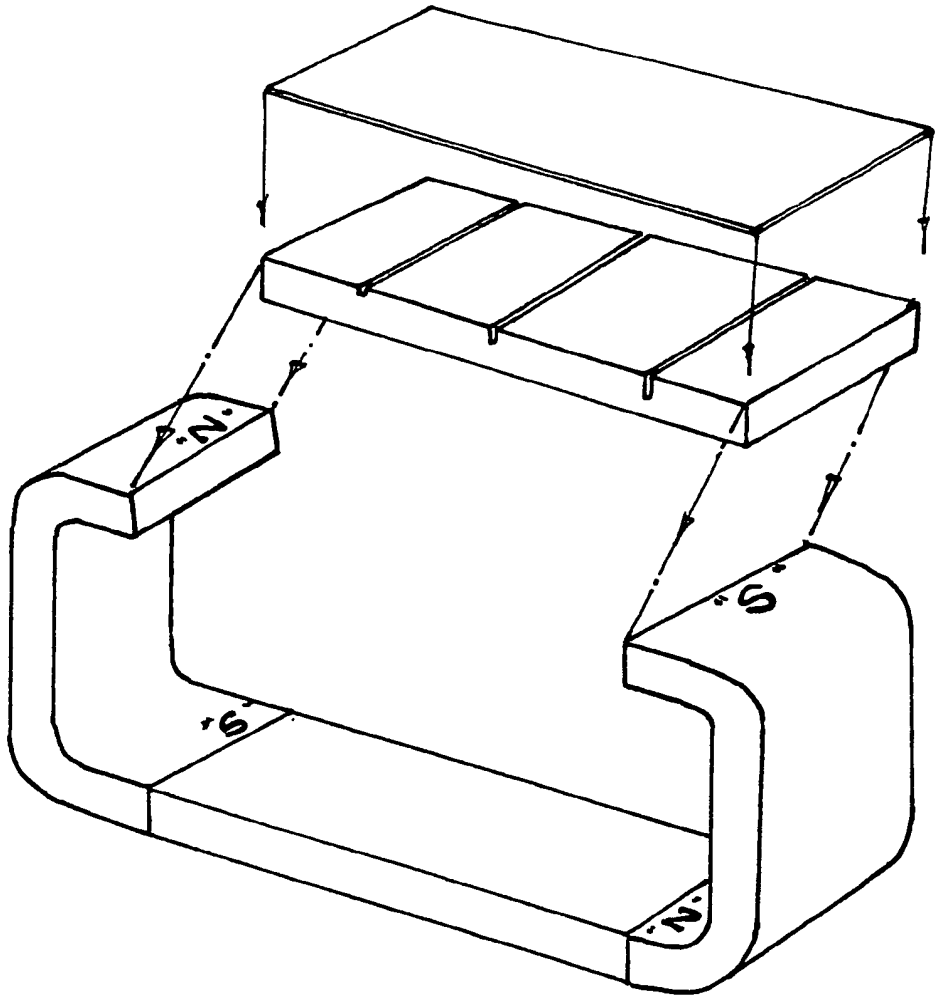

SPECIFICATION

Flaw detection method

The invention relates to methods of detecting surface flaws in magnetisable objects.

Surface flaws in magnetisable objects are commonly detected by a form of non-destructive testing known as "magnetic particle inspection". The principle of magnetic particle inspection is based on the known attraction of ferrous granules to flux leakage paths which build up around cracks or other defects in an object through which a magnetic field is being passed. Two methods are widely used.

The first of these widely used methods involves the steps of coating, for example spraying, a magnetised object with "magnetic dust" (i.e. with a cloud of ferrous particles) or with "magnetic ink" (i.e. a suspension of ferrous particles in a suitable liquid). In either case the finely divided ferrous particles are attracted to the areas of flux leakage around surface flaws, and when the excess dust has been shaken off the still-magnetised object — or when the excess liquid has drained off the magnetised surface — the pattern of ferrous particles remaining on the magnetised surface can be interpreted to give an accurate picture of any surface flaws present.

This first known method has drawbacks. Its biggest drawback is that the results obtained are not a permanent record. It is also difficult to use under water, for example in the very necessary inspection of such load-bearing underwater structures as the supporting frames and legs of oil field platforms.

The second known method is based on the use of so-called "magnetic rubber". This involves the use of a special formulation of finely divided ferromagnetic particules in room-temperature-curing liquid rubber. The material is mixed, poured onto the surface to be tested, and, whilst the material is still curing, the surface is magnetised. This causes the magnetic particles to migrate through the liquid rubber and concentrate at the location of cracks or other flaws on the surface. The rubber is then allowed to cure, the solid cast thus formed is peeled away from the surface, and examination reveals that the lines of concentrated ferromagnetic particles set into the rubber enable the surface flaw pattern to be interpreted.

This second method does give a permanent record, but it is not always as sensitive as the magnetic dust or magnetic ink method outlined above. It is very susceptible to the skill of the operator in mixing and pouring the material around the surface to be tested. The liquid material itself needs careful handling.

Worst of all, the magnetic rubber method cannot be used easily for underwater work. For that reason the magnetic dust method is usually used for underwater inspection of loadbearing surfaces. This requires an inspector who is also a trained diver to descend into the water, and spray the magnetic dust cloud around the surface, and so is expensive. The results of such an inspection rely on the integrity of the diver, and he is working under environmental restraints such as poor visibility. His work cannot easily be checked, and no record other than a written or verbal report normally results from his work.

The invention seeks to improve on these traditional methods, especially in the area of underwater flaw detection where no permanent record of the testing work is currently possible.

The invention is based on the concept of using magnetisable sheet material in a form which can relatively easily be applied to the test surface, which will give a permanent record of the test result, and which can also relatively easily be removed from the test surface without destroying that record.

According to one aspect of the invention, the magnetisable sheet material is obtained by formulating solvents, base lacquers, propellants and finely divided ferromagnetic particles containing settable pigments into an initially liquid state settable solution which, in use, is dispensed from a pressurised cannister as an aerosol on to the test surface. Upon contact with the surface, the solvents and propellants evaporate and disperse to leave a coating of lacquer containing ferromagnetic particles in suspension.

This lacquer then dries to leave a sheet in the form of a film or skin on the test surface.

If a magnetic flux is applied to the test surface, either before or immediately after application of the aerosol, the finely divided ferromagnet particles migrate through the sea of low viscosity fluid and follow the lines of flux leakage. Once the film dries to form the required skin-sheet, the particles are held permanently in the lacquer to give a permanent record of the test result.

Once cured, and after having been inspected, the dried skin can be peeled from the test surface with the minimum of distortion and then kept in a suitable folder or other receptacle for future reference.

To illustrate one way of putting this aspect of the invention into practice, the following experiment is described.

An initially liquid state settable solution was formulated by combining in appropriate proportions a suitable solvent or solvents (for example Acetone or Toluene), the liquid propellant known commercially as "Propellant 12" and whose chemical formula is CC12F2, an appropriate soluble base lacquer, finely divided ferrous oxide powder comprising not more than 10% by weight of the whole solution and with settable titanium dioxide pigmentation. This was stored in a pressurised cannister for dispensation as an aerosol.

The aerosol was sprayed in accordance with British Standard 4069 on to a test surface. In this particular experiment the surface had already been magnetised and the aerosol was sprayed over a relatively small area which was known to contain surface flaws. On contact with the surface, and after a suitable period of time of approximately one minute, the aerosol had dried to form a

flexible, strong and easily peeled film or skin approximately four-thousandths of an inch thick.

After switching the magnetising current off, the skin was viewed in adequate lighting, and the surface flaws were found to be indicated by areas of ferromagnetic particles trapped and held in position by the now cured skin.

The skin was then peeled off the surface carefully, and stored for future reference.

The formulation of the aerosol solution in this aspect of the invention can vary. Its skin-drying time could suitably not less than 30 seconds and not more than 15 minutes. The skin thickness sprayed could advantageously lie within the range from one-thousandth of an inch to five-thousandths of an inch. The aerosol could be sprayed right round the outer circumference of such components as tubes, and the resulting skin, once cured, could be carefully slit in order to be then peeled off circumferentially.

Another aspect of the invention uses the magnetisable sheet material commonly referred to as "magnetic recording tape". This material is extensively used in tape form for sound and video recording, and for computer programming. It is flexible, and can be made to conform to most surface irregularities. Once magnetised, it can be coated with known developing agents to reproduce the magnetic flux pattern on its recording surface visually. For all these reasons it lends itself ideally to the areas of use the invention envisages.

According to this aspect of the invention, a method of detecting surface flaws in a magnetisable object comprises the following steps:

a) Applying magnetic recording tape to the surface and holding the tape, recording-face-down, against the surface;

b) Magnetising the object;

c) Removing the tape from the surface; and

d) "Developing" the tape by applying a suitable magnetic ink to the recording surface.

Conveniently the magnetic ink may be applied as an aerosol spray which then dries by evaporation to leave a permanent interpretable pattern on the tape recording face.

The expression "magnetic recording tape" is not to be taken as restricting the recording material dimensionally.

Similarly the use of this expression "magnetic recording tape" is not intended to restrict the "tape" material to flexible material. Although magnetic recording tape is conventionally made of a flexible nature, and will very probably be so when used in accordance with the invention, it is conceivable that substantially rigid sheets of material could find application in certain situations.

Whether or not the "tape" is flexible, it may be reinforced, for example to withstand the relatively harsh environmental conditions encountered in underwater work, or may be backed to made it confirm to surface irregularities. To illustrate one way of putting this aspect into practice, the following experiment is described with reference to the single sheet of drawings accompanying this text.

Materials

1. (Quantity) 2 "Eclipse" Power Magnets type 812. Currently available from Neill Tools Limited, Napier Street, Sheffield S11 8HB, England.

2. (Quantity) 1 Eddy-Current Calibration Block, Ferrous. Contains three transverse slots each of 0.004 inches width and respectively 1, 0.5 and 0.2 mm depth. Available from Novalec Limited, 96 Holly Road, Twickenham, London, England, Tel. No. 01-892 3677.

3. (Quantity) 1 Keeper Block of Ferrous Steel, locally manufactured to the same dimension as the Eddy-Current Calibration Block but without any slots.

4. Magnetic Recording Tape in unused condition and of 1.00 inch width cut to 4.00 inches length (i.e. the surface dimensions of the Eddy-Current Calibration Block). Samples used for Experiment EMITAPE E 825-1097E-27FP-72819. Available from 3M Limited, Bracknell, Berkshire, England.

5. (Quantity) 1 Aerosol Container of Kyread Magnetic Tape Developer. Available from Kyros Corporation, P.O. Box 406, Madison, Winsconsin 53701, U.S.A.

6. Adhesive tape as required.

Method

The four-inch length of magnetic tape was attached recording-face-down to the Eddy-Current Calibration Block and held against the block face containing the three artificial defects (slots), fixing each opposite end of the recording tape to the block face with adhesive tape. The two power magnets and keeper were assembled as shown in the diagram, and the magnets switched on. The Eddy-Current Calibration Block was carefully inserted, with the magnetic tape affixed between the two free poles of the power magnets, and left in place for 30 seconds whilst flux flowed through the block.

After 30 seconds had elapsed, the Eddy-Current Calibration Block, complete with recording tape, was carefully removed from between the two magnets. The magnetic recording tape was then itself removed from the block face, taking care to keep the tape away from further magnetic or electromagnetic influences.

To "develop" the magnetic tape, a coating of Kyread Magnetic Tape Developer was applied from its aerosol container onto the matt recording face of the tape. The suspended ferrous particles in the developer were attracted to the invisibly recorded flux leakage indication on the tape. As the developer dried, the suspended particles became fixed in position on the tape, thereby forming a permanently recorded pattern of the flux leakage arising from the defect slots in the Eddy-Current Calibration Block.

In a further experiment, the above method was repeated underwater, and gave a similar permanent record on the developed tape. The wet

tape, removed from the block face after magnetising, was air-dried before being sprayed with the Kyread coating.

In practical situations the surface being inspected might be a welded pipe of up to approximately 10 feet in circumference where, typically, a welded band $2\frac{1}{2}$ inches wide would be inspected. The magnetic recording tape could temporarily be affixed to the area of inspection by a contact adhesive, a stretched band, or any other suitable method. Although an aerosol developer spray has been specifically described above, there are a number of other ways including brushing which could be used to apply the magnetic developing ink to the tape surface.

The Kyread coating described above was used to produce satisfactory experimental results, but for practical applications a magnetic ink comprising ferromagnetic particles suspended in an air drying varnish or other suitable carrier liquid would probably be preferred.

For similar practical reasons, although the tape used in the experiment is coloured the standard brown for magnetic recording tape, it might be possible to produce tape coloured to contrast more strikingly with the ferromagnetic particles.

CLAIMS

1. A method of detecting surface flaws in a magnetisable object and recording the pattern of such flaws for subsequent reference, the method comprising applying to the surface in question a sheet of material which, when the surface is magnetised, will become magnetised itself only in those regions which overlie the or each surface flaw and which can be removed from the test surface without destroying by such removal the flow pattern record so obtained.

2. The invention of Claim 1 and in which the sheet of magnetisable material is obtained by spraying on to the surface as an aerosol an initially liquid state settable solution of ferromagnetic particles, solvents, base lacquers and propellants which having contacted said surface adheres thereto and dries progressively to form a relatively thin skin.

3. The invention of Claim 2 and in which the skin thickness lies within the range 0.001 inches to 0.005 inches.

4. The invention of Claim 3 and in which the skin thickness is approximately 0.004 inches.

5. The invention of any of Claims 2, 3 and 4 and in which the skin drying time lies within the range 30 seconds to 15 minutes.

6. The invention of Claim 1 and in which the magnetisable sheet material comprises magnetic recording tape.

7. The invention of Claim 6 and in which the tape once magnetised and removed from the surface is developed by applying a suitable magnetic ink to its recording surface.

8. The invention of Claim 7 and in which the magnetic ink is applied as an aerosol spray which then dries by evaporation.

9. The invention of any of the preceding Claims and in which the magnetised sheet is flexible.

10. The invention of any of the preceding Claims and in which the magnetised sheet is coloured.

11. A method substantially in accordance with the first experiment described herein.

12. A method substantially in accordance with the second experiment described herein.

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